

7. CLAIMS

What is claimed is:

- 1 1. A method of inductive learning comprising:
2 receiving training data;
3 providing vectors having a set of parameters based
4 on said training data; and
5 generating a cluster database comprising clusters,
6 said clusters being associated with respective ranges of
7 values for at least a subset of said set of parameters.
- 1 2. The method of claim 1 wherein said subset of said
2 set of parameters is said set of parameters.
- 1 3. The method of claim 1 further comprising:
2 supplying, by a data acquisition module, said
3 training data.
- 1 4. The method of claim 1 wherein said training data
2 comprises archived data.
- 1 5. The method of claim 1 wherein said training data
2 comprises simulated nominal data.
- 1 6. The method of claim 1 wherein said training data
2 comprises off-nominal data.

1 7. The method of claim 1 further comprising:
2 scaling said training data associated with at least
3 one parameter of said set of parameters.

1 8. The method of claim 1 wherein said generating
2 comprises:
3 determining a distance between one of said vectors
4 and one of said clusters, and
5 producing a new cluster if said distance exceeds a
6 threshold value.

1 9. The method of claim 1 wherein said generating
2 comprises:
3 determining a distance between one of said vectors
4 and one of said clusters, and
5 expanding said one of said clusters to include said
6 vector when said distance is less than or equal to a
7 threshold value.

1 10. The method of claim 1 further comprising:
2 indexing said clusters of said cluster database
3 based on a distance of each of said clusters from a
4 predetermined indexing reference point, and
5 organizing said clusters into a data structure based
6 on said indexing.

1 11. A method of monitoring a system comprising:
2 providing a cluster database comprising clusters,
3 said clusters being associated with respective ranges of

4 values for at least a subset of a set of cluster
5 parameters;

6 receiving one or more monitored-system vectors
7 having monitored-system parameters; and

8 determining whether said monitored-system vector is
9 contained in one of said clusters based on at least a
10 subset of said monitored-system parameters and said at
11 least a subset of said cluster parameters.

1 12. The method of claim 11 further comprising:

2 if one of said monitored-system vectors is not
3 contained in one of said clusters, determining a distance
4 of said one monitored-system vector from a nearest of
5 said clusters, wherein said distance is associated with a
6 severity of a deviation.

1 13. The method of claim 12 wherein said determined
2 distance provides a comparison result for each monitored-
3 system vector, further comprising:

4 supplying said monitored-system vectors and said
5 comparison result associated therewith to another
6 learning application.

1 14. The method of claim 11, further comprising:

2 examining said monitored-system vectors to determine
3 if any parameter is erroneous; and

4 if any parameter of one of said monitored-system
5 parameters is erroneous, adjusting said erroneous
6 parameter such that said parameter will match any range

7 specified for said parameter in any cluster of said
8 cluster database.

1 15. The method of claim 11 further comprising:
2 providing an additional cluster database, the
3 clusters of said additional cluster database being
4 associated with respective ranges of values for at least
5 a subset of said set of parameters, said additional
6 cluster database being annotated with diagnostic
7 information; and
8 if one of said monitored-system vectors is not
9 included in one of said clusters, comparing said one of
10 said monitored-system vectors with said clusters of said
11 additional cluster database.

1 16. An article of manufacture comprising a computer
2 program usable medium embodying one or more instructions
3 executable by a computer for performing a method of
4 inductive learning, the method comprising:
5 receiving training data;
6 providing vectors having a set of parameters based
7 on said training data; and
8 generating a cluster database comprising clusters,
9 said clusters being associated with respective ranges of
10 values for at least a subset of said set of parameters.

1 17. The article of manufacture of claim 16 wherein said
2 subset of said set of parameters is said set of
3 parameters.

1 18. The article of manufacture of claim 16, said method
2 further comprising:
3 supplying, by a data acquisition module, said
4 training data.

1 19. The article of manufacture of claim 16 wherein said
2 training data comprises archived data.

1 20. The article of manufacture of claim 16 wherein said
2 training data comprises simulated nominal data.

1 21. The article of manufacture of claim 16 wherein said
2 training data comprises off-nominal data.

1 22. The article of manufacture of claim 16, said method
2 further comprising:
3 scaling said training data associated with at least
4 one parameter of said set of parameters.

1 23. The article of manufacture of claim 16 wherein said
2 generating the cluster database comprises:
3 determining a distance between one of said vectors
4 and one of said clusters, and
5 producing a new cluster if said distance exceeds a
6 threshold value.

1 24. The article of manufacture of claim 16 wherein said
2 generating a cluster database comprises:

3 determining a distance between one of said vectors
4 and one of said clusters, and
5 expanding said one of said clusters to include said
6 vector when said distance is less than or equal to a
7 threshold value.

1 25. The article of manufacture of claim 16, wherein said
2 method further comprises:

3 indexing said clusters of said cluster database
4 based on a distance of each of said clusters from a
5 predetermined reference point.

1 26. An article of manufacture comprising a computer
2 program usable medium embodying one or more instructions
3 executable by a computer for performing a method of
4 monitoring a system, the method comprising:

5 receiving one or more monitored-system vectors
6 having monitored-system parameters; and

7 determining whether said monitored-system vector is
8 contained in a cluster of a cluster database comprising a
9 set of clusters, said clusters of the set being
10 associated with respective ranges of values for at least
11 a subset of a set of cluster parameters, said determining
12 being based on at least a subset of said monitored-system
13 parameters and said at least a subset of said cluster
14 parameters.

1 27. The article of manufacture of claim 26, wherein said
2 method further comprises:

3 if one of said monitored-system vectors is not
4 contained in one of said clusters, determining a distance
5 of said one monitored-system vector from the nearest of
6 said clusters, wherein said distance is associated with a
7 severity of a deviation.

1 28. The article of manufacture of claim 27 wherein said
2 determined distance provides a comparison result for each
3 monitored-system vector, said method further comprising:
4 supplying said monitored-system vectors and said
5 comparison result associated therewith to another
6 learning application.

1 29. The article of manufacture of claim 26, wherein said
2 method further comprises:

3 if any parameter of one of said monitored-system
4 parameters is erroneous, adjusting said erroneous
5 parameter such that said parameter will match any range
6 specified for said parameter in any cluster of said
7 cluster database.

1 30. The article of manufacture of claim 26, wherein said
2 method further comprises:

3 if one of said monitored-system vectors is not
4 included in one of said clusters, comparing said one of
5 said monitored-system vectors with clusters of an
6 additional cluster database, said clusters of said
7 additional cluster database being associated with
8 respective ranges of values for at least a subset of said

9 set of parameters, said additional cluster database being
10 annotated with diagnostic information.

1 31. An apparatus for inductive learning comprising:
2 a computer; and
3 one or more computer programs, executed by said
4 computer, for:
5 receiving training data;
6 providing vectors having a set of parameters based
7 on said training data; and
8 generating a cluster database comprising clusters,
9 said clusters being associated with respective ranges of
10 values for at least a subset of said set of parameters.

1 32. The apparatus of claim 31 wherein said subset of
2 said set of parameters is said set of parameters.

1 33. The apparatus of claim 31, wherein said one or more
2 computer programs also for:
3 supplying, by a data acquisition module, said
4 training data.

1 34. The apparatus of claim 31 wherein said training data
2 comprises archived data.

1 35. The apparatus of claim 31 wherein said training data
2 comprises simulated nominal data.

1 36. The apparatus of claim 31 wherein said training data
2 comprises off-nominal data.

1 37. The apparatus of claim 31, wherein said one or more
2 computer programs also for:
3 scaling said training data with at least one
4 parameter of said set of parameters.

1 38. The apparatus of claim 31 wherein said generating
2 comprises:
3 determining a distance between one of said vectors
4 and one of said clusters, and
5 producing a new cluster if said distance exceeds a
6 threshold value.

1 39. The apparatus of claim 31 wherein said generating
2 comprises:
3 determining a distance between one of said vectors
4 and one of said clusters, and
5 expanding said one of said clusters to include said
6 vector when said distance is less than or equal to a
7 threshold value.

1 40. The apparatus of claim 31, wherein said one or more
2 computer programs, executed by said computer, further
3 comprises, for:
4 indexing said clusters of said cluster database
5 based on a distance of each of said clusters from a
6 predetermined indexing reference point.

1 41. An apparatus for monitoring a system, comprising:
2 a computer having a memory storing a cluster
3 database comprising clusters, said clusters being
4 associated with respective ranges of values for at least
5 a subset of a set of cluster parameters; and
6 one or more computer programs, executed by said
7 computer, for:
8 receiving one or more monitored-system vectors
9 having monitored-system parameters; and
10 determining whether said monitored-system vector is
11 contained in one of said clusters based on at least a
12 subset of said monitored-system parameters and said at
13 least a subset of said cluster parameters.

1 42. The apparatus of claim 41, said determining also for,
2 if one of said monitored-system vectors is not contained
3 in one of said clusters, said determining determines a
4 distance of said one monitored-system vector from the
5 nearest of said clusters, wherein said distance is
6 associated with a severity of a deviation.

1 43. The apparatus of claim 42 wherein said determined
2 distance provides a comparison result for each monitored-
3 system vector, said one or more computer programs further
4 comprising:
5 supplying the monitored-system vectors and their
6 associated comparison result to another learning
7 application.

1 44. The apparatus of claim 41, said one or more computer
2 programs also for examining said monitored-system
3 vectors, and, if any parameter of one of said monitored-
4 system vectors is erroneous, said examination adjusts
5 said erroneous parameter such that said parameter will
6 match any range specified for said parameter in any
7 cluster of said cluster database.

1 45. The apparatus of claim 41, wherein said memory also
2 stores an additional cluster database, the clusters of
3 said additional cluster database being associated with
4 respective ranges of values for at least a subset of said
5 set of parameters, said additional cluster database being
6 annotated with diagnostic information; and

7 wherein, if one of said monitored-system vectors is
8 not included in one of said clusters, said determining
9 compares said one of said monitored-system vectors with
10 said clusters of said additional cluster database.